LIGHT WEIGHT FAN BLADE CONTAINMENT SYSTEM

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a fan blade containment system for use with an aircraft turbofan engine. An important requirement in modern aircraft turbofan engines in commercial service is that they retain fan blades or fan blade pieces which may break off during engine operation. Fan blade failure can occur for a variety of reasons, but is commonly caused when a bird, hailstone or any other foreign object strikes the engine fan while the engine is in operation. If a fan blade or blade fragment is not retained by a suitable containment system, the blade or blade fragment—which travels at a high velocity upon failure—can cause serious damage to parts of the aircraft. It is therefore necessary to provide some containment system near the engine fan for retaining any blade or blade fragments which break off the engine fan during operation. Such a containment system should be provided near the point where fan blade failure will cause the blade or blade fragment to travel.

2. Description of the Related Art

Fan blade containment systems have been previously proposed for use in turbofan engines. The objective of such containment systems has been to provide adequate retention of fan blade fragments without increasing the overall weight of the engine shroud, thereby decreasing engine performance. Certain prior art containment systems utilized a metallic honeycomb structure for retaining fan blade fragments—examples of these types of systems can be found in U.S. Pat. Nos. 3,126,149; 4,063,847; 4,377,370; 4,452,565; 4,534,698; 4,547,122; 4,666,371; 4,705,454; 5,188,505; "Development of Advanced Lightweight Systems Containment: Final Report," C. L. Stotler (N.A.S.A., May 1981) and "Containment of Composite Fan Blades: Final Report," C. L. Stotler and A. P. Coppa (N.A.S.A, July 1979). Other prior art systems show the use of a fibrous or fabric band wrapped around the interior portion of the engine shroud as a mechanism for fan blade retention—for example, U.S. Pat. Nos. 4,038,118; 4,063,847; 4,377,370; 4,411,589; 4,425,080; 4,452,565; 4,452,563; 4,534,698; 4,699,567; 4,705,454; 4,718,818; 4,818,176; 4,902,201; 4,961,685; "Development of Advanced Lightweight Systems Containment: Final Report," C. L. Stotler (N.A.S.A., May 1981) and "Containment of Composite Fan Blades: Final Report," C. L. Stotler and A. P. Coppa (N.A.S.A, July 1979). Other prior art systems disclose the use of ceramics as a part of an overall fan blade retention system—for example, U.S. Pat. Nos. 4,289,447; 4,547,122; 4,646,810; 4,818,176 and "Development of an Advanced Fan Blade Containment System," Alan D. Lane (F.A.A., August 1989).

SUMMARY OF THE INVENTION

It is desirable when providing a fan blade containment system that the system be as lightweight as possible, while still retaining good blade retention characteristics. Furthermore, such a system should prevent penetration of fan blade fragments into the interior of the engine nacelle, where it may cause damage to hoses or other components necessary to the proper operation of the engine. Any containment system must also reduce or eliminate the possibility that blade fragment impacts will dislodge portions of the containment system, which portions can also cause damage to the engine or other portions of the aircraft. Finally, such a system should be resistant to rupture or fragmentation caused by the impact of sharp fan blade fragment edges.

It is the object of the present invention to provide a fan blade retention system which is extremely lightweight, which retains failed fan blades so as to prevent damage to portions of the aircraft and which is not itself damaged by fan blade impacts so as to cause damage to the engine, engine components, or to the aircraft itself. Containment systems which rely on fibrous materials as a retention mechanism are often subject to sequential failure of fibrous bands caused by cutting of the bands by a sharp blade fragment. The present invention avoids this problem by using ceramic tiles to blunt sharp edges and to reduce the momentum of blade fragments, so as to resist cutting of the fibrous retention band. The instant invention also prevents the ceramic tiles from releasing large chips—which chips can themselves cause additional engine damage—by encapsulating the tiles in an elastomeric material.

The present invention accomplishes the need for a lightweight, failure-resistant containment system by the use of a unique combination of elastomer-coated ceramic tiles, as well as lightly bonded fabric layers overlaying the layer of ceramic tiles. The resulting structure is of much lighter weight than previous fan blade retention systems, reduces tearing of the fabric layer by fan blade fragments which may reduce the effectiveness of the containment system, and prevents fan blade impacts from causing the release of large tile fragments, which could lead to engine damage.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a schematic representation of the containment system of the present invention;

FIG. **2** is a cross-sectional schematic representation of the hard facing layer and fibrous backing layer of the present invention;

FIGS. **3***a* and **3***b* are cross-sectional schematic representations of two alternative configurations of the fibrous backing layer of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

FIG. **1** shows a schematic representation of the fan blade containment system **1** of the present invention. The fan blade containment system **1** consists of a conventional fan case **2** manufactured of, e.g., steel, aluminum, titanium, or any other lightweight, high-strength material, to which a hard facing layer **3** is bonded. Wrapped around the hard facing layer **3** is a fibrous backing layer **4**. The containment system **1** of the present invention surrounds a turbofan engine fan **10** to retain any fan blades or fan blade fragments dislodged from the engine fan **10**.

FIG. **2** shows a cross-sectional schematic representation of the hard facing layer **3** and fibrous backing layer **4** of the present invention. The hard facing layer consists hard facing tiles **5**, made of either a ceramic material or of hardened metal. If the hard facing tiles **5** are constructed of ceramic, these tiles can be constructed of, e.g., alumina, silicon carbide, boron carbide, titanium diboride, or aluminum nitride. If the hard facing tiles **5** are constructed of a hardened metal, a heat treated steel may be used. In general, a low density ceramic—prefer-